DOCUMENT RESUME

ED 206 046 EA 013 764

AUTHOR Fredrick, Wayne C.; Walberg, Herbert J.
TITLE Learning as a Function of Time.
INSTITUTION Illinois Univ., Chicago. Chicago Circle Campus.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE [80]
GRANT NIE-678-0090
NOTE 38p.: Not available in paper copy due to broken print of original document. This document is Part J of a compilation entitled "Generalized Theory of Design and Analysis of Educational-Effectiveness Research." For related documents, see EA 013 759-761, EA 013 763-767, ED 168 714, ED 185 064, and EJ 210 984.

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Academic Achievement; Language Acquisition; *Learning; Measurement Techniques; Models; *Outcomes of Education; Reading Skills; Student Attitudes; *Time Factors (Learning)

ABSTRACT

To examine the relationship between time and in-school learning, the authors review a number of empirical and theoretical studies covering all educational levels. They discuss the methods and interpretations of the empirical studies, the effects of time on learning outcomes and of other variables on time-on-task, and the incidence of diminishing returns to learning from added school or study time. Four methods of measuring time are identified, including years of schooling, days of instruction at school, hours of classes during the day, and minutes of study during class. The authors summarize the effects of these types of time on academic achievement, knowledge, IQ, language and reading level, failure rate, adjustment to school, and attitudes toward education, schoolwork, teaching, religion, and modern life. They also examine two theoretical models relating time to learning: the acceleration model, which allows time to vary until the task is mastered, and the enrichment model, which holds time constant while allowing the amount of learning to vary. From the studies reviewed, the authors conclude that time is a modest predictor of student learning. (RW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)
☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ED206046

Learning as a Function of Time

Wayne C. Fredrick
Dept. of Research & Evaluation
Board of Education

Herbert J. Walberg
University of Illinois
at Chicago Circle

EA 013 761

This review concerns learning in school settings as dependent upon quantity of instruction. In natural settings of learning, the quantity variable is measured at several levels. Accordingly, studies in this review are grouped into four sections on the basis of the magnitude of the time measure used: Years of Schooling, Days of Instruction, Hours of Classes, and Minutes of Study. The review concludes with a fifth section, Theories about Time and Learning.

Time is most often treated in the literature as an independent variable or as one of the predictors in regression; but it is also occasionally used as a dependent variable, for example, the effect of motivation on amount of study. Both types of dependence are discussed. Several studies of time are presented in detail to exemplify important theoretical, methodological, and interpretative points. If vitiating design, analysis, or interpretive problems are detected in a study, these are also discussed.

Years of Schooling

Achievement and Knowledge

Hyman, Wright, and Reed (1975) provide evidence on the association between years of schooling and knowledge. Based on reanalysis of 54 national surveys conducted during 1949 to 1971 involving 80,000 respondents,

the results clearly show differences in knowledge associated with attained levels of schooling. In the varied types of items, years of schooling showed deginite effects on 95% of the 250 items of knowledge. Data from a 1966 survey, for example, show that 93% of the college graduates knew the meaning of "pact," while only 77% of secondary school graduates and 28% of elementary school graduates could define the word. Such monotonic changes by education level held in surveys of the humanities, geography, science, civics, and other fields. Added years of education also had the general effect of increasing the level of newspaper reading, magazine and book reading, and movie going, but not TV viewing and radio listening. The more educated also had more interest in politics, public affairs, health and education.

The results for various sub-populations were reasonably similar, although there were several interesting discrepancies. Item effects, for example, were weaker in older people: at ages 49-60, about 90% of the items showed the monotonic increase in knowledge with each level of schooling, but only 80% showed it for the 61-72 year age group. The effects of education, however, were generally equal for men and women, for Roman Catholics and Protestants, and for immigrants and native born. After attempts to control for social class, effects were somewhat reduced. The mean correlation between years of schooling and knowledge decreased from .26 to .22 when social class differences were removed by partial correlation. For higher social classes, however, the partial correlations indicating the effects of level of education were frequently increased.

As the investigators acknowledge, it is difficult to say whether people know more because they attended school longer or attended school

longer because they were more capable. Other survey research studies, discussed next, introduce additional control techniques that permit better assessment of such alternative explanations. The Hyman et al. reanalysis does show, however, that schools open an avenue to knowledge, even to the children of the less well educated.

Knowledge and IQ

Two large surveys show the positive correlation between years of schooling on one hand, and factual knowledge about a wide variety of subjects on the other.

Harnqvist (1968), in a unique longitudinal study of the relation of IQ change to amount of schooling, collected ability test data in 1961 on a 10 percent sample of Swedish children, about 5000, in the sixth grade of elementary school and, for the same group, their scores on military-service mental tests taken five years later at approximately age 18. Students who obtained only a compulsory education of from seven to nine years, depending on local school district requirements, declined three-tenths of a standard deviation in relative intellectual level; but those who went on to university preparatory schools increased three-tenths. The difference between the two groups corresponded to about ten IQ points. With home background controlled, the difference was reduced to about 7.5 points; and, with this control, each additional year of compulsory achool was associated with about 2.5 additional IQ points.

The National Assessment of Educational Progress (1976) staff tested a national sample of young adults, ages 26 to 35, on basic skills that are ordinarily covered in elementary school: computation and measurement, graph and reference materials, writing, and manual and perceptual skills.

Harnqvist (1977) pointed out that the college graduates scored 30 to 40 percentage points higher in all these areas than those that finished only the nine years of school. These differences are not completely attributable to schooling, since college graduates may have been more able at ninth grade or may have reviewed these earlier learnings after leaving elementary school.

Modernity

Inkeles and Smith (1974) carried out a sophisticated cross-sectional survey of modernity in six developing countries. They operationally defined modernity as openness to experience, readiness for social changes, present or future rather than past orientation, belief in self-efficacy, and related attitudes and opinions. About 700 urban industrial workers and several hundred other adults were interviewed in each of the countries--Argentina, Chile, East Pakistan, India, Israel, and Nigeria; and modernity scores were singly and multiply related to years of schooling, months of factory experience, objective skill, mass-media exposure, urban experience, modernity of the home-school setting, father's education, and number of consumer goods possessed.

Years of schooling correlated more strongly and consistently with modernity than with any other variable. The simple correlations of schooling and modernity ranged from .41 to .71 across the six countries, with a median of .52; corresponding partial correlations, with the other socialization variables controlled, ranged from .25 to .52 with a median of .34. On the 64-point range of the modernity scale, each additional year of schooling was associated with about a 2-point increment in modernity, with the other socialization variables controlled. The Inkeles and Smith research is exemplary for its cross-cultural replication,

comprehensive set of independent variables, and consistency of time effects when statistically controlled for rival causes.

Religiosity

A number of investigators examined the relation of the years or level of Roman Catholic or Jewish religious schooling and religious attitudes and behavior (see Himmelfarb, 1977, and Greeley, McCready, and McCourt, 1976, for references and review). In several respects, Himmelfarb (1977) conducted the most sophisticated analysis of the relation, although the return rate on his mailed survey to about 5,000 adult Jews in Chicago, 30.4 percent, and the useable rate, 17.3 percent, are far less than optimal. From a 41-item self-report scale of Jewish religious attitude and practice he covaried out parental, spouse's, and friend's Jewish religiosity and other background factors which accounted for 58 percent of the variance, and calculated adjusted religiosity means for combinations of years and types of Jewish schooling, which were found significantly different.

What is more exemplary is that Himmelfarb estimated the total hours of Jewish schooling by summing instructional hours of attendance in Saturday, afternoon, and day school. He plotted mean adjusted religiosity against class intervals of hours ranging from 0-749 to 13,001-13,750. Religiosity was lower for the interval 750-1,250 hours, which suggests this group contained alienated early dropouts. But religiosity increased fairly steadily from 1,251 to about 3,750 hours where it reached a plateau extending out to 13,750 hours. Across 12 years of schooling, the fitted relation suggests steadily increasing returns from 2 to 6 hours per week; negative returns from 0 to 2 hours; and no returns for greater than 6 hours per week.

Himmelfarb's analysis points up four methodological implications.

First, the powerful covariance analysis, a special case of generalized regression, allows fairly convincing causal inference. However, self-selection, distance of the school from the home, and other factors unaccounted for in the analysis may affect both attendance and religiosity.

Second, amount of instruction is estimated precisely in hours rather than only in years or the general categories of none, some, and much. However, using narrower class intervals or even exact point estimates would have been even more precise than grouping individuals into the class intervals of 500 or more hours.

Third, the plot showing the relation of adjusted religiosity means and amounts of instruction highlights the non-linearity. In addition, however, it would be desirable to estimate the actual regression. It is not clear from the plot that the threshold and plateau effects are statistically significant. By testing also the regression of the religiosity on the logarithm of instructional hours as suggested by the diminishing-returns relation (discussed in a subsequent section), perhaps a single coefficient of slope and a constant might fit the data nearly as well as three separate slopes and constants for each apparent phase of schooling's effects--negative, increasing, and plateau.

Fourth, in addition to total instructional hours in the regression, it would be useful to include hours in different types of schools separately in other regressions to check the possibility that one type of schooling is more intensive in its effect than others.

Language Acquisition

Until recently, language acquisition was often thought to depend more on maturation or early sensitivity of the young child than to amount of formal or informal exposure to the language environment.

McLaughlin's (1977) review of 162 anthropological, psychological, and educational studies, however, shows that it remains to be proven that young children learn language more (or less) quickly or easily than adults, and that second-language learning involves different processes, dependencies, or rates than does first-language learning.

A way to separate maturation from exposure effects is to analyze the acquisition levels of children of different ages who have been exposed to the same and different amounts of a second language. Because the children studied thus far, such as the French in Montreal and Spanish surnamed in U.S. cities, are exposed to a simultaneous but varying mix of two languages, the research results are equivocal (McLauglin, 1977). Moreover, small samples and gross classifications of exposure, such as over and under three years, have limited the conclusions that may be drawn.

Walberg, Hase, and Rasher (1977) exploited an opportunity to study one of the few sizable and accessible groups in the United States that is exposed to a sharp change from one language to another, the sons and daughtexs of Japanese businessmen and academics on assignment in this country. The children had lived from 0 to 12 years in Japan and 0 to 12 years in the United States. Although the 360 children attend Japanese school on Saturdays, they attend public schools and play with American children in their neighborhoods scattered throughout the Chicago metropolitan area for the rest of the week. A simple regression of self-rated and teacher-rated proficiency in English speaking, writing, reading, expression of feelings and concepts, and other scales on the logarithm of the number of months in the United States produced correlations of from .52 to .62 which were not raised by adding the number of months in Japan or product terms to the equation

to test the age and early sensitivity hypotheses.

The logarithm provided a consistently better fit than did untransformed months in the States, which suggests rapid gains in proficiency in the early months and a gradually diminishing rate of gain over time; that is, proficiency continues to increase for children of all ages but at a diminishing rate. According to the self ratings, equal ease in reading Japanese and English is reached on average in 34 months. According to the American teacher rating, Japanese students reach their average American classmate's reading proficiency in English after 42 months. Additional gains beyond these points are small and come very slowly.

Although the strength of relation, and precision and parsimony of the regression fit in the study are reasonably high for field data in behavioral research, the conclusions would be strengthened by objective performance tests. Construction of such tests would be difficult since they would have to be used with both a wide age and ability span; moreover, several types of tests, for example, listening and writing would be necessary. An easier way to improve the precision of the estimated relation would be to assess average daily English exposure and usage, and possibly their qualities or intensities, as a refinement of the number of months of U.S. residence.

Days of Instruction

Achievement

Coleman et. al. (1966) initiated much interest regarding time. Their study of 93 variables including six "time" variables generated controversy because so little of the variation in achievement was apparently associated with the school measures. In a nationwide sample of 6th, 9th and 12th graders tested on general information, reading, math, and verbal and non-verbal abilities, blocks of variables were entered into step-wise regression equations. The blocks, including the time variables --hours of homework and attendance rate--accounted for 4% additional variance in the Black sample and 1½% in the White sample, after other blocks such as home background and student characteristics had been entered. Other variables such as frequency of homework, days in session, part day attendance, and length of academic day had even less predictive power in Coleman's analyses.

Wiley and Harnischfeger (1974) presented arguments that questioned the results of these small effects due to schooling and presented reanalyses of Detroit data from the Coleman sample. Using 6th grade achievement data, the school-level regression equations indicated that "... where students receive 24 percent more schooling, they will increase their average gain in reading comprehension by two-thirds and their gains in mathematics and verbal skills by more than one-third. These tremendous effects indicate that the amount of schooling a child receives is a highly relevant factor for his achievement" (p. 9). By extrapolation, they projected that increases in the length of the school year, or in the attendance rate, or in the length of the school day could each have high expected payoffs in achievement.

Karweit (1976), however, showed with another reanalysis that the Wiley and Harnischfeger conclusion was suspect. She used the Coleman data for Detroit and other cities, grades 3, 6, 9, and 12, and added data from Maryland, grades 3, 5, 7, and 9. When the Detroit data were split into city and suburban sets, time was no longer significant; this suggests school policies or sample differences rather than time may account for the differences in achievement.

The coefficients for time were also much smaller in her Maryland analysis. The variable she used for quantity was the log of the product of three variables--daily attendance rate, hours in school day, and days in school year. She later found that the coefficient for days in school year, taken separately, was negative, and thus it would have reduced the effect of the other time variables in the aggregated log product.

In the Coleman data the effect for attendance was, however, quite strong when estimated separately for the 9th and 12th grade data. But attendance did not account for much variance in the Maryland data. Also, 1964-65 data from McDill on high schools was analyzed by Karweit using the individual student as the unit of analysis. Again small effects due to attendance were noted, not the large effects the Wiley and Harnischfeger found.

Karweit concluded that the nature of the relationship between time and achievement is still poorly understood. There may be effects that are strongly cumulative that are not picked up by the analysis used in cross-sectional designs; and the relationship may not be linear. She noted specific problems with the variable itself. The quantity measures may interact, as when a longer school year is associated with increased absenteeism. Also, the range of a variable such as attendance is very limited, especially in the lower grades where attendance is uniformly high.

Failure Rate

Walberg and Rasher (1977) tested a time variable that was the product of length of school year and average rate of attendance. This and 18 other variables were tested by regression equations for association to the failure rate on Selective Service tests in all 50 states. The product which they called effective attendance did not have a significant weight (only two variables did, the percent of students enrolled in the public schools and the pupil-teacher ratio.) The reader should note that this product is very similar to the time variables that Karweit tested and found to interact. The product varies differently than simple attendance or simple length of school year. Unpublished analyses by Walberg and Rasher, however, indicated that neither raw nor transformed components of the product when entered separately were significant.

Beginning Reading

The Southwest Regional Laboratory field-tested the Ginn Kindergarten Program in 1972-73 (Hanson and Schutz, 1975). The schools in the California sample were urban, suburban and rural. The Beginning Reading Program (BRP) was used during the year for part of the curriculum. Time was recorded as number of instructional days spent on the BRP materials; and the dependent variables were reading skills and units of BRP completed. Time correlated .69 with the number of units completed. Time correlated .50, .44, .32, and .51 with number of words read, work elements recognized, letter names known, and sentence reading skill, respectively.

Hanson and Schutz reasonably concluded that, "The data consistently support the explanation that the differences in BRP performance among the various categories of users results from differences in the number of days

spent on BRP instruction rather than any differential effectiveness of the program for pupils with different biosocial characteristics" (p. 54).

The relatively high correlations with time were perhaps obtained due to special care to account for other variables that normally reduce the correlation. The material was new, not previously taught, so that students may have begun from zero. Teachers stuck to a specified role in their relationship to the units. This may have significantly reduced the usual differences that teachers might be able to introduce into most studies. The test was specifically designed for the outcomes of the units, insuring a sensitive measure of the effects of study of the BRP units.

Gain in Achievement

Summers and Wolfe (1975) used data from all the public schools in Philadelphia to construct regression equations. The dependent variables were achievement growth from 3rd to 6th grade, 6th to 8th, and 9th to 12th. The student was the unit of analysis rather than classrooms or schools; and the variables were tested for their association with the differences between two scores for the same student at different grades.

To give an indication of how looking at gain differs from looking at absolute scores, Summers and Wolfe showed that at each level the variables entered into the equations explained much less of the variance in gain than of the absolute score. All the variables, which included measures of community, home, school, teacher and student characteristics, explained 74%, 85%, and 58% of the absolute achievement at grades 6, 8, and 12, respectively, but only 28%, 31%, and 32% of the gain for 3-6, 6-8, and 9-12, respectively.

Most past research employing regression to detect educational effects explicitly places pretests and other "control" variables such as student background in the regression rather than employing regression-residualized or raw gain scores. Although the issue is still controversial, the majority of methodologists continue to caution against gain scores. Placing control variables in the regression directly makes for one analysis rather than two, affords comparisons with prior work, allows their weights to emerge in the analysis, permits the calculation of interaction product terms, and avoids statistical procedures that are questioned by some writers. Such advocacy should not be taken as dismissing research that employs gain scores.

The individual time variables that had significant weights in the Summers and Wolfe study were number of days present, number of unexcused absences, and latenesses and dropouts.

For younger students, latenesses and unexcused absences had a negative weight in the equations. The impact of these differed for the students at different income levels. At third to sixth grade ~~growth~~ for non-poverty students, five additional absences per year would reduce growth by 2.1 months, but only 1.3 months for students from poverty level. Five additional latenesses per year

would imply 2.9 months less growth for students at the poverty level, but 1.2 months less for those of average income levels.

In the sixth to eight grade ~~growth~~ five additional unexcused absences implied .8, or 1.7, or 2.3 months less growth for low, average, and high achieving students, respectively. Whatever the causes or the consequences of the absences, they have a higher negative impact on student growth as the achievement level increased. Total days present, however, had an effect across all income and achievement levels. Ten additional days present implied .5 months more growth.

Twelfth grade ~~grade~~ growth was significantly related to latenesses, unexcused absences and dropouts. Five additonal latenesses or absences produced about half a month less growth. Lateness affected the high achiever more than the average achiever.

Reading Comprehension

Agrawal (1977) analyzed the reading comprehension scores of all tested eleven-year-olds in 470 public schools of Chicago. Two successive years, 1975 and 1976 were analyzed separately. Fourteen variables were entered into regression, using school as unit of analysis; five of these variables explained 86% of the variance in the 1975 data, 77% in the 1976 data. Four of these were community and student characteristics, namely poverty level, percent Caucasian students, percent non-English speaking and size of school. The percent of highly experienced teachers was the fifth. Time was entered in in the form of the percent of attendance. It did not have a significant beta weight, largely because attendance correlated highly with the community and student variables.

Simple correlations between attendance and reading comprehension were .72 in 1975 data and .66 in 1976 data. When controlled for poverty the partial correlations for '75 and '76 were .30 and .27, respectively. These analyses suggest that less time is spent on learning in poor neighborhoods and therefore the effects of time and poverty on learning are difficult to disentangle.

Fredrick, Walberg, and Rasher (1978) used 24 Chicago high schools in a regression study of several time variables. Time lost due to classroom observed absences, lateness, early departures, interruptions to the lesson, wasted time, and lack of student involvement were tabulated and combined into a single index of effective instructional time. After controlling for prior performance, the effective time entered the equation and had a significant regression weight, along with number of positive comments and attendance alone. The more time used effectively in the school, the higher the reading comprehension scores tended. The correlation between effective instructional time and reading score was .54, with prior performance partialled out, it was .35.

The close relationship between community measures and attendance shown above in the Agrawal study suggests that student background predicts both achievement and attendance, or that background and attendance are so closely linked that the separate effect of attendance cannot be estimated, especially when it does not vary widely from school to school. But attendance can be given a greater precision by keeping track of actual in-class study time as done in the Fredrick, Walberg, and Rasher study.

Hours of Classes

Achievement

Colemans' data (1966) reporting the marginal predictive success of length of academic day and hours of homework dealt with variables in this time range. The Fredrick et. al (1978) study also involved some variables at this level as a composite measure. The other studies here include measures of how time within a day is spent.

Leinhardt (1977) used a sample of second graders in seven Follow-Through sites and from three Pittsburg schools. Standardized achievement tests provided the data, which was aggregated at the classroom level. Teachers were given a questionnaire on classroom practices, providing 18 variables. Videotapes of teaching procedures were rated for each of 20 variables for all classes. Record cards in math and reading provided additional information about student achievement.

Four time variables--attendance, time spent reading, time spent on math, and time spent in large group instruction -- were combined into a single index and used to predict achievement. The time index, called "opportunity to learn," correlated .20 with achievement. The partial correlation was .27 when prior achievement was controlled. Another variable, autonomy, which included measures of the student initiative in beginning work on their own, correlated .26 with achievement with prior achievement controlled.

Leinhart noted that prior level accounted for 83% of the output variance and the other indexes explained an additional 5% of the regression predictions. But the small amount of additional variance explained is deceptive, Leinhart argued. The prior level and the other cluster are confounded, and in fact

36% of the variance is common to each. Leinhardt explains, "... classroom practices which relate positively to outcomes occur more frequently in classrooms with children with higher entering performance" (p. 291).

The variance contributed to process decreased over the years, 14% in 1972, 7% in 1973, and 5% in 1974. Quoting again, "... as classroom processes became more and more stable over time across grade levels, the power of entering student performance to explain end-of-year performance is likely to increase" (p. 291). The correlation of time with output was about as high as any of the variables being tested, the range for the whole group of them being -.40 to .28.

This low but persistent effect of time variables is shown by Husen (1972) in the IEA study of mathematics achievement in twelve different countries. Length of school week, time given to homework, and time for instruction accounted for 3% of the variance in achievement in math for 13-year-olds. Time devoted to instruction was near significance in all 12 countries.

In a re-analysis of these results for Belgium, England, West Germany, Scotland, Sweden, and U.S.A., Lindsey (1974) used a more complex procedure to find the optimum combination of variables to explain achievement in math. Lindsey concluded from his response-surface analysis that "... there is an optimum number of hours for instruction for these programs in all countries ..." (p. 324).

For classes of 28 students, the optimal time in the U.S.A. was about 2½ to 4 hours per week for students from the upper socio-economic classes. It was 3½ to 4 hours for those in the middle classes and in vocational programs. Less than 3½ and more than 4 hours per week were each associated with lower scores. In larger classes the optimal time was slightly more.

The same general optimums were also seen clearly in data from Scotland, middle classes in Sweden, the general program in West Germany, and the middle and lower classes of England. Lindsey noted that one cannot conclude that hours of instruction cause higher or lower scores in a country, and that hours of instructions can be a response to problems with math as well as being an independent variable.

Subject Areas

Wolf (1978) examined the regression equations between achievement scores in different subject areas and blocks of predictor variables, including time for three large samples of American students, 10 and 14 years old, and 12th graders. Block 1 variables included measures of home environment, student and family characteristics, and community descriptors. Block 2 variables includes the type of school and program. Block 3 included type of instruction, teacher variables and time. Block 4 included measures of student attitudes, activities, and interests. The variables were entered into the equations in the stepwise order listed. Two levels of analysis were used, the school and the student.

When the school was the unit of analysis and reading comprehension the achievement variable, Block 1, entered first, explained an average of 62% of the variance for the three samples. Block 2 added nothing. Block 3 added 3% more explanatory power and Block 4 added 5%. For achievement in literature and science, Block 1 averaged 54%, with a definite declining trend as the samples were older. Block 3 variables in literature explained an added 7% for 14 year olds and 22% for 12th graders. In science, Block 3 explained 8, 11, and 19% of the added variance in the 10 year, 14 year, and 12th grade samples, respectively. Wolf argued effectively that as the subject area was more totally school taught the Block 3 variables became better

predictors. Literature and science are more predominantly school learned than reading, which can be more easily picked up from non-school sources.

The time variables included time spent in classroom instruction in a subject and time spent doing homework in a subject. The correlation between hours of homework in literature achievement scores was .59 for the 14 year olds, .16 for the 12th graders. In science the similar correlations were .53 and .46.

When the student was the unit of analysis, the correlations were generally lower, but the extent to which the subject was school learned showed more clearly in the regressions. For listening skills in French, for example, the time variables were entered separately and explained an added average of 32% of the variance after the Blcok 1 and 2 variables. For reading skill in French, time explained an added 16%.

For the other subjects; reading comprehension, science, literature, and civic education, the Block 3 variables added an average of 4% to the explanatory power of the regressions. The correlations of time with achievement when the student was the unit of analysis ranged from .15 to .40.

Wolf was careful to point out that regression explains variations in student performance but it does not explain level of performance. He concluded that "... the longer students are exposed to school instruction in a subject, the greater the statistical effect of instructional variables in the subject" (p. 9). But on the other hand, "... the influence of single instructional variables is weak" (p. 14).

Rath (Note 1) reported a study involving 68 fifth-grade classrooms in Southern Maryland. Time allocated to the teaching of social studies in minutes per day correlated .21 with a standarized, social-studies achievement test, the percent of time-on-task correlated .13 with achievement, and attendance rate correlated .35 with achievement. In the regressions of

achievement on IQ and raw and log time variables, time carried small, significant weights in the equations.

Quality of School Life

Epstein and McPartland (1976) developed a Quality of School Life (QSL) scale and used it as an independent variable. The QSL had subscales on satisfaction with school, commitment to learning, and reaction to teaching. In validating the scale, several measures of time were tested for their relationship to the QSL.

The QSL correlated -.29 with amount of cutting school, -.27 with cutting classes, .29 with hours of homework, .34 with industriousness, and .30 with participation level. The satisfaction subscale shared common variance with absence rate and participation level, and commitment shared it with participation level, perceived industriousness and homework.

Sanderson (1976) referred to time as a better predictor of achievement than IQ, especially when willingness to spend time on a subject is measured. Time spent relates to locus of control, attending behavior in class, favorable disposition, involvement, and having goals. Sanderson treated time as a dependent variable to be predicted by student satisfaction with mastery learning. The sample was 86 tenth graders in English classes in a prep school in upstate New York. Students worked through a series of mastery learning units on grammar, literature and writing.

For males, time and achievement had a tau of .23, females .38. Time and previous year's achievement for males .24, females .10. Sanderson interpreted these correlations as showing that the boys weren't so ready to change their study behavior, but girls were. The multiple correlation of involvement, educational acceptance, and satisfaction in predicting time was .59.

Minutes of Study

Level of Adjustment

Werner and Simpson (1974) selected first graders whom teachers had classed as either well adjusted, moderately adjusted, or poorly adjusted. All students were from large suburban schools in the midwest, half in open classrooms, the other half in traditional. Attention to task was measured at intervals during a series of 50-minute class periods and correctly completed work in reading was recorded over a 30-day period. The students judged well adjusted averaged 88% of time attending to task, moderately averaged 81% and poorly averaged 66% attending. The difference was significant at the .05 level, but differences for open versus traditional classrooms were not significant. Students also differed by percent of work correct: well adjusted, 88%; moderately, 82% and poorly, 69%.

They concluded that the child's adjustment level was a salient determiner of how much time the student attends to the task and how much correctly done work is produced. An alternative explanation is that these same criteria may be salient factors in how teachers judge the adjustment level of their students.

Attitudes

McMillan (1977) gave two assignments to classes of university students in a 2 by 2 design. Half received a high effort assignment that required a considerable time in preparing the answer to a questions about a book. The others needed only to list points briefly. Positive or negative praise was given to half of each group, and then Likert scales measured their attitudes toward the task, the content, and the praise. The student who spent the most time in preparing the assignment had more positive attitudes toward the task, and positive praise interacted with more minutes spent to produce even higher positive feelings.

Achievement

Bell and Davidson(1976) observed 23 teachers of grades 4, 5, and 6 for four days each. They recorded the percentage of time that pupils were kept on task and recorded it for 462 students. Achievement was measured by the scores made on teacher-prepared tests of the units being studied during the observed time. Correlations were run between time on task and test scores, and these averaged .25 across the 23 classes; the range was -.14 to +.67. IQ was partialled out to give an average partial correlation of .21 with a range of -.12 to +.64.

Sjorgen (1967) used adults who studied programmed lessons under three conditions of time. By using time spent on one lesson as an estimate of time needed on others, he showed that the ratio in the Carroll model -- time spent/time needed -- did predict the degree of learning. The ratio correlated with achievement scores significantly (.45 to .52 for different groups), but with ability controlled in terms of WAIS scores, the partial correlations were much smaller (.09 to .29).

Bennett (1976) in a comparison of teaching styles in elementary schools in Britian zeroed in on the time spent in actual learning activities as an important reason for the different performance of students in formal and informal classrooms. The students in formal classes learned more and also spent more time working. In reading, mathematics, and English, high achievers spent 21, 23, and 17 percent more time, respectively, in work activity than did the low achievers.

Bloom (1976) reports correlations averaging .60 between time on task and achievement.

Diminishing Returns

Two empirical studies are mentioned in this section because they broaden the evidence on the theoretical relation of time and achievement to unusual areas that are untreated in other sections and because they exemplify the diminishing returns relation also shown in the work of Karweit (1976), Walberg, Hase, and Rasher (1977), and Wiley and Harnischfeger (1974) discussed in other sections.

Wells, Whelchel, and Jamison (1975) regressed mathematics posttest achievement on pretest achievement, years of teacher experience, teachers score on a 100-item verbal test, teacher degree level and self-efficacy, student self-efficacy, and number of supplementary computer-assisted instruction sessions for a sample of 446 fifth-and sixth-grade students. Generally for the various forms of the equations and breakdowns of the sample by grade and sex, taking logarithms of the variables provided a higher multiple correlation and more precise fit of achievement to the number of CAI sessions. The results suggest that achievement in relation to amount of supplementary CAI practice shows positive but diminishing returns.

Such log-log regressions are known as Cob-Douglas production functions in economics, and Walberg (1978) argues that their properties of diminishing marginal returns and substitutability of production factors may be useful in regression studies of educational achievement, especially when variables are measured over their full latent range. A useful property of such Cob-Douglas regressions is the uniform and ready interpretability, because the raw regression weight is the estimated percentage increase in achievement associated with a one percent increase in time (or any other independent variable). Such interpretability and ready comparability may be important enough in their own rights even if the transformations do not always make for better fitting regressions.

Bloom (1976) estimates that the slowest ten percent of students may need 5-6 times as much time to learn as the most rapid ten percent, but they are usually not given this much extra time. Rarely are such large ratio encountered for variables in educational research. In a typical class, for example, the highest and lowest IQs might be 120 and 80, and the extreme scores on a 50-item achievement test might be 45 and 30; both ratios are 1.5 to 1. Educational measurements are severely limited in range and reliability; their floors are high and the ceilings low. Even so, when achievement is related to time, the regression often turns out to be logarithmic in the wide variety of studies mentioned in this review, especially in those in which time varies considerably. A final quantitative example: Arthur (1977) shows in swim training data that at "1,000 yards a day one reaches 75% of the maximum training effort, and at 2,000 yards, 85%. In order to reach 95% of maximum, one needs to go 10,000 yards a day in training, and to get 99% to 100% one would need to go 16,000 yards a day" (p. 2) which would take as long as eight hours. The variance accounted for by a logarithmic regression is .96 in contrast to .87 for the linear equation. Although such things as ballet, music, chess, science, and writing performance cannot be measured so precisely, they appear to show diminishing returns relative to time: good or even excellent performance by the usual standards may only require a half to an hour a day of concentrated effort; but national rankings or one's best may require, among other things; three to ten hours of instruction and practice daily (pushing past some point, of course, may produce not only diminishing but negative returns).

Diminishing marginal returns to time can often be well fitted by logarithmic transforms and can only be crudely approximated in linear regression and perhaps missed entirely by grouping data into class intervals. To make a good estimate of the relation would require reasonably wide and reliable variation of time as well as achievement; moreover, interpolation within such data can be made more confidently than extrapolating beyond the range of narrow,

colinear factors. A rival hypothesis to diminishing achievement returns, however, that requires investigation with wide-ranging tests, is that more and more students peak out on the conventional test's low ceiling as time goes by; that is, the test is incapable of detecting true linear returns at the upper range.

Theories about Time and Learning

Theoretical Models

It may be said that conceptions of time and learning may be grouped under two broad points of view--acceleration and enrichment (Walberg, 1971, 1975). In both conceptions, learning is thought to be function of ability and time, other things being equal. In enrichment, which is by far the more prevalent, time remains constant for all students; and the normal curve of achievement is a function of the normal curve of initial ability. In acceleration, now often termed mastery, a fixed criterion level of achievement is chosen which students are given varying time to achieve. Enrichment programs often assume that the achievement test samples the universe of content items that might be asked and often compare the scores of students with one another for grading. Acceleration programs often assume that the test comprises the universe of content and compare student mastery with the possible universe by taking percentages correct on tests.

Both conceptions may be represented in the regression:
Learning = a + b(ability) + c(time) + error, where a is a constant and b and c are the estimated regression weights which estimate the amount of increased learning associated with a one-unit increment, respectively, in ability and time. This is the usual formulation found in research on time. A Cobb-Douglas form simply requires taking logarithms of all three variables before regression.

For a given criterion amount of achievement or "mastery" in acceleration models of school learning it seems reasonable to say that, other factors being equal, moderate-aptitude students require relatively moderate amounts of time; the brighter students require conrrespondingly less; the duller, correspondingly more. Extrapolating such additive reasoning to extremes, however, produces the absurd conclusions that geniuses learn instantaneously and that the feeble-minded require just a little more time than the subnormal. Walberg (1978) argues that

aptitude and time multiplicatively substitute or compensate for one another, other things being equal, at diminishing rates of marginal returns; ever larger amounts of time, approaching a poorly-measured asymptote at infinity, are required to substitute for equal decrements of aptitude and vice versa. Thus, to attain the highest performance levels will require at least a small amount of time for a genius; and an immense, possibly prohibitive amount will be required by the dull. Such relations can be tested by taking logarithms of the variables in the above equation (Cobb-Douglas form). Similarly, time may compensate, with diminishing returns, for poor quality instruction or less adequate home environment.

The instructional theories of Carroll (1963), Bloom (1976), and Harnishfeger and Wiley (1976) may be interpreted as acceleration models within the production-theory framework. Carroll's formulation

$$\text{Degree of learning} = f\left(\frac{\text{time actually spent}}{\text{time needed}}\right)$$

where "the numerator of this fraction will be equal to the smallest to the following three qualities: 1) opportunity--the time allowed for learning, 2) perservance--the amount of time the learner is willing to engage actively in learning, and 3)--the amount of time needed to learn, increased by whatever amount necessary in view of the poor quality of instruction and lack of ability to understand less than optimal instruction. This last quality (time needed to learn after adjustment for quality of instruction and ability to understand instruction) is also the denominator of the fraction" (Carroll, 1963, p. 730). Recast in the production function: 1) opportunity becomes quantity of instruction, that is, time allowed including self-instructional time; 2) perserverance becomes motivation (although an observer rating the percentage of engaged time is a reasonable proxy or even a more direct though expensive measure); 3) time needed becomes unadjusted ability; and 4) quality of instruction explicitly enters the equation rather than adjusting ability. Thus, rather than redefining all the independent variables in terms of time, the production function

would assess the direct effect of each measured factor (including student age, the home environment, and the social environment of the class because of their known connections with achievement) in an explicit equation form.

Bloom's (1976) adaption of the Carrol model may be written

$$\begin{pmatrix} \text{Level and Type of Achievement,} \\ \text{Affective Outcomes} \\ \text{Rate of Learning} \end{pmatrix} = f \begin{pmatrix} \text{Quality of Instruction,} \\ \text{Cognitive Entry Behaviors,} \\ \text{Affective Entry Behaviors} \end{pmatrix}$$

In the production function, affective outcomes would be considered a particular type of achievement possibly involved in a feedback loop with motivation for subsequent achievement. Instead of measuring time to reach a criterion or gain in achievement divided by time to obtain a rate, time would directly enter the equation as an independent variable, quantity of instruction. The other variables have obvious correspondences in the production function. Thus, the sets of re-defined variables in the Carroll and Bloom models may be hypothesized to show substitutability and diminishing returns of the function.

The usual problems of operational definition, measurement, and lack of factor variation may account for the occasional lack of significant fit of learning to time, but the production function suggests that misspecification may also be a problem. Bringing more of the production factors into the equation, finding data in which time varies over a greater range, and taking logarithms may help considerably. More specifically, the form of the production function suggests non-linear relations among time and the other factors that seem more conceptually defensible than the linear assumptions that pervade the research.

The Harischfeger and Wiley (1977) model distinguishes different types of classroom events and hence argues for specificity in measuring time that is instructionally used as opposed to that which fulfills other purposes. In the model, the teacher's on-task time and the students' on-task time both enter

the production function. Out-of-class time is also included in the model, a need that was demonstrated by the entry of hours of homework as a predictor of achievement in several studies reviewed here. As Kifer (1975) argued "....addition of time-related variables in the home should increase the explanatory power of 'time' models and provide a means to explore further the effects of academic achievement on the personality characteristics of the learner" (p. 208). Accordingly, Harnischfeger and Wiley rightly call not only for more specific measures of classroom time components but also study time outside of school.

Conclusion

Learning is produced in schools in a context of many variables that affect its efficiency. These variables are sometimes located within the student, or reside in the method of instruction, or in the relationship of the student to others in the environment, or in the skills of the people responsible for instruction, or in the physical structure. Invariably one of the variables operating is time, time spent in homework, on a lesson, during a school year, or in a lifetime of schooling.

The other variables have their effects, other things being equal, to the ~~variables have their effects, other things being equal, to the~~ extent that they are given time to work.

Time devoted to school learning appears to be a modest predictor of the achievement students will evidence. For some type of new material where each student is qualitatively using study time advantegeously, time becomes the best predictor, as in the Hanson and Schutz (1975) study. When material is familiar, often taught, or imprecisely measured, then time is marginal or insignificant, or displays non-linear effects such as the diminishing returns cited earlier. To the extent that additional time is used to make up for ineffective instruction or poor performance, more time may be negatively correlated with achievement.

It is apparent that, in schools, time can be easily lost. See for example Fredrick (1977) Cusick (1973) and Sava (1977). On the other hand, the time in one classroom can be used radically differently than in another even though the same content is ostensibly being taught. See for example Berliner (1978).

Kifer (1977) may have come closest to a productive understanding of time and its relationship to achievement. Time, he says, is a proxy for the process variables that ought to be measured. Thus, as Carroll (1975) showed in a study of proficiency in the French language, a teacher can reduce the amount of time needed by students to achieve a certain level of performance. Quite clearly this is evidence that a teacher can make a difference. So, too, can a student, for when a student becomes motivated to learn French, an operational measure of this motivation is the time that the student is willing to spend.

In a recent survey of high school administrators (Duke, 1978) who were asked to rank discipline problems, the top three rankings involved the loss of instructional time: skipping class, truancy, and lateness. This survey shows the practical importance of time in the minds of school administrators. This review indicates its theoretical and empirical importance from a wide variety of perspectives, even though its effects cannot always be well estimated either because it is poorly measured, is confounded with student background variables, or varies over a limited range. Quantity of instruction should be a strong candidate for inclusion in many educational research studies as a potentially manipulable policy variable under the partial and joint control of educators, parents, and students or as a control variable to estimate more precisely the effects of other educational variables such as the quality of instruction.

Reference Notes

1. Walberg, H. J., Wase, K., & Rasher, S. P. English acquisition as a diminishing-returns function of time rather than age. TESOL Quarterly, 1978, (in press).

2. Fredrick, W. C., Walberg, H. J., & Rasher, S. P. Time, teacher comments, and achievement in urban high schools. (Under review.)

3. Wolf, R. M. Achievement in the United States. Mimeographed advance copy to be published in Walberg, H. J. (Editor), Educational Environments and Effects. Berkeley: McCutchan, 1978.

4. Raths, J., personal communication, December, 1977.

5. It is important to note that the Cobb-Douglas form, like the restricted linear model in the equation above, requires the estimation of only three coefficients in ordinary least-squares regression. To estimate diminishing returns, substitution with a general linear model requires the addition of square terms for ability and time as well as their product which calls for a total of six coefficients for estimation. Thus the restricted linear model and, in cases where diminishing-returns are hypothesized or suspected, the Cobb-Douglas form, are not only more parsimonious but result in more stable coefficients for replication.

6. Berliner, D. C. Tempus Educare. (Unpublished manuscript, 1978).

References

Agrawal, K. C., Smith, J., & Wick, J. W. Achievement in relation to school characteristics. (Mimeographed report), Chicago: Department of Research and Evaluation, Board of Education, 1977.

Arthur, R. J. Masters swimming program stimulates physical fitness. Swim-Master, 1977, 6, 1-2.

Bell, M. L., & Davidson, C. W. Relationships between pupil-on-task performance and pupil achievement. The Journal of Educational Research, 1976, 69, 172-176.

Bennett, N. Teaching Styles and Pupil Progress. Cambridge: Harvard University Press, 1976.

Bloom, B. S. Human Characteristics and School Learning. New York: McGraw-Hill, 1976.

Carroll, J. B. A model of school learning. Teachers College Record, 1963, 64, 723-733.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. "Pupil Achievement and Motivation." Chapter 3 in Equality of Educational Opportunity. U. S. Office of Education OE-38001, Washington, D. C.: U. S. Department of Health, Education, & Welfare, 1966.

Cobb, C. W., & Douglas, P. H. A theory of production. American Economic Review Supplement, 1928, 23, 139-165.

Cusick, P. A. Inside High School. New York: Holt, Rinehart, & Winston, 1973.

Epstein, J. L., & McPartland, J. M. The concept and measurement of the quality of school life. American Educational Research Journal, 1976, 13, 15-30.

Duke, D. L. How administrators view the crisis in school discipline. Phi Delta Kappan, 1978, 59, 325-330.

Fredrick, W. C. The use of classroom time in high schools above or below the median reading score. Urban Education, 1977, 11, 459-464.

Greeley, A. M., McCready, W. C., & McCourt, K. Catholic Schools in a Declining Church. Kansas City: Sheed & Ward, 1976.

Hanson, R. A., & Schutz, R. E. The effects of programmatic R & D on schooling and the effects of schooling on students. Technical Report 53, Southwest Regional Laboratory for Educational Research and Development, 1975.

Harnischfeger, A., & Wiley, D. E. The teaching-learning process in elementary schools: A synoptic view. Curriculum Inquiry, 1976, 6, 5-43.

Harnischfeger, A., & Wiley, D. E. Conceptual issues in models of school learning. Studies of Educative Processes, (Report #10) Chicago: CEMREL, Inc., 1977.

Härnqvist, K. Changes in intelligence from 13 to 18. Scandinavian Journal of Psychology, 1968, 9, 50-82.

Härnqvist, K. Enduring effects of schooling: A neglected area in educational research. Educational Researcher, 1977, 6, 5-11.

Himmelfarb, H. S. The non-linear impact of schooling: Comparing different types and amounts of Jewish education. Sociology of Education, 1977, 42, 114-129.

Husén, T. Does more time in school make a difference? Education Digest, 1972, 38, 11-14.

Hyman, H. H., Wright, C. R., & Reed, J. S. The Enduring Effects of Education. Chicago: University of Chicago Press, 1975.

Inkeles, A., & Smith, D. H. Becoming Modern. Cambridge, Mass.: Harvard University Press, 1974.

Karweit, N. A reanalysis of the effect of quantity of schooling on achievement. Sociology of Education, 1976, 49, 236-246.

Kifer, E. Relationships between academic achievement and personality characteristics: A quasi-longitudinal study. American Educational Research Journal, 1975, 12, 191-210.

Leinhardt, G. Program evaluation: An empirical study of individualized instruction. American Educational Research Journal, 1977, 14, 277-293.

Lindsey, J. K. A re-analysis of class size and achievement as interacting with four other critical variables in the IEA mathematics study. Comparative Education Review, 1974, 18, 314-326.

McLaughlin, B. Second-language learning in children. Psychological Bulletin, 1977, 84, 435-457.

McMillan, J. H. The effect of effort and feedback on the formation of student attitudes. American Educational Research Journal, 1977, 14, 317-330

National Assessment of Educational Progress. Adult Work Skills and Knowledge. Career and Occupational Development Report No. 05-COD-01, 1976.

Sanderson, H. W. Student attitudes and willingness to spend time in unit mastery learning. Research in the Teaching of English, 1976, 10, 191-198.

Sjorgen, D. D. Achievement as a function of study time. American Educational Research Journal, 1967, 4, 337-344.

Summers, A. A., & Wolfe, B. L. Which school resources help learning? Efficiency and equity in Philadelphia public schools. Business Review, (Published irregularly by the Federal Reserve Bank of Philadelphia.), 1975.

Walberg, H. J. Models for optimizing and individualizing school learning. Interchange, 1971, 2, 15-27.

Walberg, H. J. Psychological theories of educational individualization. In Talmage, H. (Editor), Systems of Individualized Education. Berkeley: McCutchan, 1975.

Walberg, H. J. Educational productivity. In Walberg, H. J. (Editor), Educational Environments and Effects: Evaluation, Policy and Productivity. Berkeley: McCutchan, 1978.

Walberg, H. J., & Rasher, S. P. The ways schooling makes a difference. Phi Delta Kappan, 1977, 58, 703-707.

Welch, W. W., & Bridgham, R. G. Physics achievement gains as a function of teaching duration. School Science and Mathematics, 1968, 449-454.

Wells, S., Whelchel, B., & Jamison, D. The impact of varying levels of computer-assisted instruction of the academic performance of disadvantaged students. Princeton, N. J.: Educational Testing Service, 1975.

Werner, C. S., & Simpson, R. L. Attention to task and completion of work as a function of level of adjustment and educational environment. Journal of Educational Research, 1974, 68, 56-58.

Wiley, D. E., & Harnischfeger, A. Explosion of a myth: Quantity of schooling and exposure to instruction, major educational vehicles. Educational Researcher, 1974, 4, 7-12.